

# S/X Experiment: DSS 14 S/X Ground System Ranging Tests

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*This article presents special ranging test data obtained on the S/X ground system at DSS 14. The test data consist of ground system range as functions of (1) uplink 100-kW transmitter power, (2) downlink S- and X-band signal levels, and (3) antenna elevation and azimuth angles via the cable path and via the airpath.*

## I. Introduction

On 1974 Day 12, a new configuration was installed at DSS 14 for ground system ranging calibrations. As described in Ref. 1, this new configuration differs from the conventional one in that the zero delay device (ZDD) uplink and downlink signals are transmitted through calibrated cables instead of through the airpath. Some limited amount of range calibration data on this new configuration was previously reported in Ref. 1.

Due to unexpected doppler stability problems with the Block 4 receiver system during the period 1974 Day 47 through 85, it was difficult to perform useful ranging tests on the S/X system until after the Mariner 10 Mercury encounter on 1974 Day 88.

This article presents results of some recent ranging tests made on the S/X ground system at DSS 14 as functions of various ground station parameters. Pre- and post-

track calibration data for the Mariner 10 tracking passes and discussion of S/X calibration problems are discussed in the preceding article of this volume (T. Y. Otoshi, "S/X Experiment: DSS 14 Pre- and Post-Track Ranging Calibration for Mariner 10 Tracking Passes and Associated Problems).

## II. Test Configuration

A block diagram of the present ZDD configuration for the S/X ground system calibrations at DSS 14 may be seen in Fig. 1. As was described in Ref. 1, the ZDD is a ground station antenna-mounted transponder that samples the uplink 2113 MHz from the transmitter and generates coherent downlink S- and X-band test signals of 2295 MHz and 8415 MHz. Transmission of these test signals to the respective masers is possible either through a cable path or a microwave airpath by means of an internal coaxial switch in the ZDD assembly.

As may be seen in Fig. 1, the present ground system configuration being calibrated at DSS 14 consists of the Block 3 exciter, the 100- or 20-kW transmitters, the S/X masers, Block 4 receivers, and the Mu-2 ranging machine. Test data were reduced in real time at DSS 14 by means of the Engineering Calibration Program (DOI-5399-SP), which was specially developed for the S/X Experiment.<sup>1</sup> A sample output from the program may be seen in Fig. 2. This program has many of the features of the Monitor Program (DOI-5046-OP), and can be used to test range and cumulative doppler phase at any DSN station having the Block 3/Planetary Ranging Assembly (PRA) ranging or Block 4/Mu-2 ranging systems. The program is currently in the DSN Program Library and copies of tapes and documentation have been sent to all stations in the DSN including CTA 21.

### III. Test Results

Special tests were performed to investigate range as functions of (1) uplink 100-kW transmitter power, (2) downlink S/X signal levels, and (3) antenna elevation and azimuth angles.

Data from special tests obtained with the Engineering Cal Program are presented in graphical form in Figs. 3 through 14. Figures 3 and 4 show plots of round-trip range delay as functions of uplink power from the 100-kW transmitter. It can be seen that the variation of delay is less than 2 ns for either the S- or X-band system when the transmitter power is varied from 75 kW to 100 kW.

Figures 5 through 8 show round-trip range delays as a function of received signal level as defined at the input to the Mod 3 S-band maser and X-band maser. Range is found to be significantly dependent upon signal level when Receiver 4 of the Block 4 system is used for either S- or X-band and less dependent when Receiver 3 is operated for either S- or X-band. In the signal level range of  $-135$  dBm to  $-145$  dBm, the range change is approximately 0.3 ns/dB for Receiver 3 and 0.8 ns/dB for Receiver 4. Tests with the signals injected behind the respective S- and X-band masers showed the same type response and therefore ruled the masers out as possible causes of range change with signal level. Further tests on the Mu-2 ranging machine as well as manual gain control

(MGC) tests on the Block 4 receivers resulted in the isolation of the Block 4 automatic gain control (AGC) loop as being the source of the range changes.

Special tests were also made to study the effects of antenna elevation and azimuth movement on range. The results of these tests for the cable path configuration may be seen in Figs. 9 through 12. The variations of 6 ns as functions of elevation angles in the S-band cable path are larger than reported previously (see Ref. 1). The variations could be due to changes somewhere in the 100-kW Klystron Amplifier Assembly. This fact can be verified in the future by performing a similar test with both the Block 4 translator and the ZDD and comparing the results. This test should give a valid indication since the ZDD samples the uplink signal after the Klystron Amplifier, while the Block 4 translator obtains the uplink signal from the exciter assembly in front of the Klystron Amplifier.

Figures 13 and 14 show the results of range tests with the ZDD in the airpath configuration. The large variation of about 25 ns in the airpath for the X-band is about the same as was reported previously in Ref. 2. The cause of this change in range is still not known. Several tests were made to isolate possible multipath signals in the airpath. One test involved the temporary installation of an RF screen that interconnected the rooftops of the three cones mounted on the Tricone Support Structure. This screen covered the open area between the three cones and blocked potential S- and X-band leakage signals. A small improvement was noticed at S-band and a small (but insufficient) improvement at X-band was also obtained. Another screen placed around the dichroic plate assembly support structure resulted in no further improvement at X-band. Another test showed that the performance of the X-band airpath range could be improved significantly by axial focusing of the subreflector at each elevation angle for optimum antenna gain at X-band. However, optimizing for X-band seriously affected the S-band performance. Although the strange behavior in the airpath is not clearly understood at present, it is felt that airpath tests are still useful for trouble shooting potential problems in the S/X reflex feed system.

### IV. Conclusion

Data from special ranging tests on the S/X system at DSS 14 have been presented. These data may be useful for indicating improvement areas needed on the ground

<sup>1</sup>This program was written by Harvey Marks of Informatics, Inc., Canoga Park, California.

system for future missions such as Viking '75. In addition, these data could be helpful in explaining some of the ranging anomalies seen during the Mariner 10 mission (Refs. 3 and 4). It has been reported that part of the struc-

tured noise in the differenced range versus integrated doppler (DRVID) data seen in the Mariner Venus/Mercury 1973 mission was correlated to ground station received signal level changes (Ref. 5).

## References

1. Otoshi, T. Y., and Stelzried, C. T., "S/X Experiment: A New Configuration for Ground System Range Calibrations With the Zero Delay Device," in *The Deep Space Network Progress Report 42-20*, pp. 57-63, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1974.
2. Stelzried, C. T., Otoshi, T. Y., and Batelaan, P. D., "S/X Band Experiment: Zero Delay Device Antenna Location," in *The Deep Space Network Progress Report 42-20*, pp. 64-68, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1974.
3. Spradlin, G., *Simultaneous Two-Way/Three-Way DRVID Tests*, IOM 421G-74-197, May 17, 1974 (JPL internal document).
4. Chaney, W. D., *Range Calibration Discrepancies During MVM-73*, IOM NSE-74-105, May 8, 1974 (JPL internal document).
5. Rourke, K. H., *Viewgraphs from DRVID Investigation Initial Phase Report*, IOM 391-8-180, June 5, 1974 (JPL internal document).

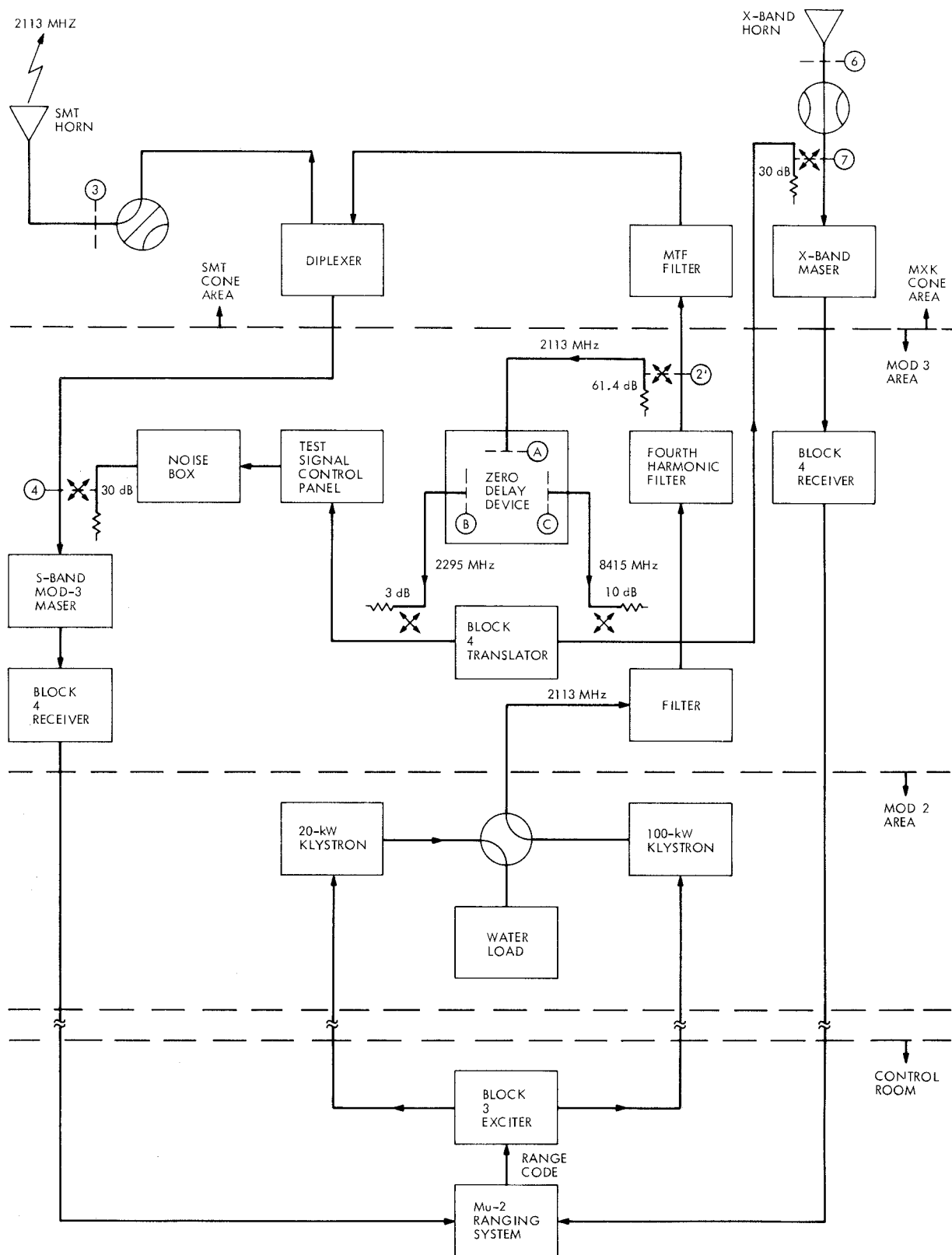


Fig. 1. Block diagram of the new configuration at DSS 14 for ground system range calibrations

200 CABLE CONFIG												
DAY	ISY	AZ(DEG)	EL(DEG)	SR(USEC)	XR(USEC)	DR(USEC)	SP(DEG)	XP(DEG)	DP(DEG)			
01124107	219.998	10.002	.0031	3.4677	3.3656	.1022	.0	18.0	-4.9			
01124112	219.998	10.002	.0031	3.4677	3.3656	.1022	18.0	18.0	13.1			
01124117	219.998	10.002	.0031	3.4677	3.3656	.1022	18.0	54.0	3.3			
01124122	219.998	10.002	.0031	3.4677	3.3656	.1022	.0	18.0	-4.9			
01124127	219.998	10.002	.0027	3.4679	3.3655	.1025	.0	18.0	-4.9			
01124132	219.998	10.002	.0027	3.4679	3.3655	.1025	18.0	18.0	13.1			
01124137	219.998	10.002	.0027	3.4679	3.3655	.1025	.0	18.0	-4.9			
01124142	219.998	10.002	.0027	3.4679	3.3655	.1025	18.0	36.0	9.2			
01124147	219.998	10.002	.0040	3.4680	3.3655	.1025	18.0	.0	18.0			
01124152	219.998	10.002	.0040	3.4680	3.3655	.1025	.0	36.0	-9.8			
01124157	219.998	10.002	.0040	3.4680	3.3655	.1025	.0	36.0	-9.8			
01125102	219.998	10.002	.0035	3.4682	3.3654	.1028	18.0	36.0	8.2			
01125107	219.998	10.002	.0032	3.4681	3.3655	.1026	18.0	54.0	3.3			
01125112	219.998	10.002	.0032	3.4681	3.3655	.1026	.0	54.0	-14.7			
01125117	219.998	10.002	.0032	3.4681	3.3655	.1026	-18.0	18.0	-22.9			
01125122	219.998	10.002	.0032	3.4681	3.3655	.1026	.0	36.0	-9.8			
01125127	219.998	10.002	.0035	3.4682	3.3654	.1028	18.0	36.0	8.2			
01125132	219.998	10.002	.0035	3.4682	3.3654	.1028	.0	18.0	-4.9			
01125137	219.998	10.002	.0035	3.4682	3.3654	.1028	.0	18.0	-4.9			
01125142	219.998	10.002	.0035	3.4682	3.3654	.1028	.0	.0	.0			
01125147	219.998	10.002	.0035	3.4683	3.3654	.1029	18.0	.0	18.0			
01125152	219.998	10.002	.0035	3.4683	3.3654	.1029	.0	36.7	-9.8			
01125157	219.998	10.002	.0035	3.4683	3.3654	.1029	.0	36.0	-9.8			
01126102	219.998	10.002	.0035	3.4683	3.3654	.1029	18.0	18.0	13.1			
01126107	219.998	10.002	.0042	3.4683	3.3653	.1030	-18.0	18.0	-22.9			
01126112	219.998	10.002	.0042	3.4683	3.3653	.1030	.0	18.0	-4.9			
01126117	219.998	10.002	.0042	3.4683	3.3653	.1030	18.0	18.0	13.1			
01126122	219.998	10.002	.0042	3.4683	3.3653	.1030	18.0	18.0	13.1			
01126127	219.998	10.002	.0052	3.4682	3.3653	.1029	.0	36.0	-9.8			
01126132	219.998	10.002	.0052	3.4682	3.3653	.1029	.0	18.0	-4.9			
01126137	219.998	10.002	.0052	3.4682	3.3653	.1029	.0	36.0	-9.8			
01126142	219.998	10.002	.0052	3.4682	3.3653	.1029	.0	18.0	-4.9			
01126147	219.998	10.002	.0036	3.4683	3.3653	.1030	.0	18.0	-4.9			
01126152	219.998	10.002	.0036	3.4683	3.3653	.1030	.0	36.0	-9.8			
01126157	219.998	10.002	.0036	3.4683	3.3653	.1030	.0	18.0	-4.9			
01127102	219.998	10.002	.0036	3.4683	3.3653	.1030	18.0	36.0	8.2			
01127107	219.998	10.002	.0035	3.4684	3.3652	.1032	.0	36.0	-9.8			

Fig. 2. Sample printout page from Engineering Cal Program (DOI-5399-SP) showing S/X DRVIDs, S/X updated ranges, and S/X doppler phases (DSS 14 test data on 1974 Day 157)

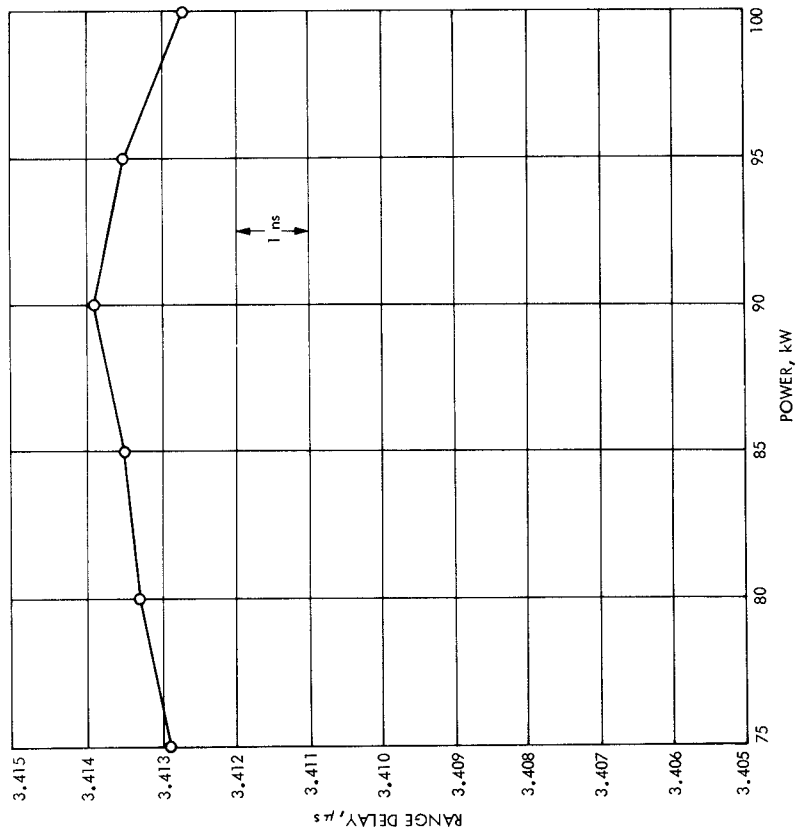


Fig. 4. 100-kW transmitter power vs ZDD X-band range on 1974 Day 75

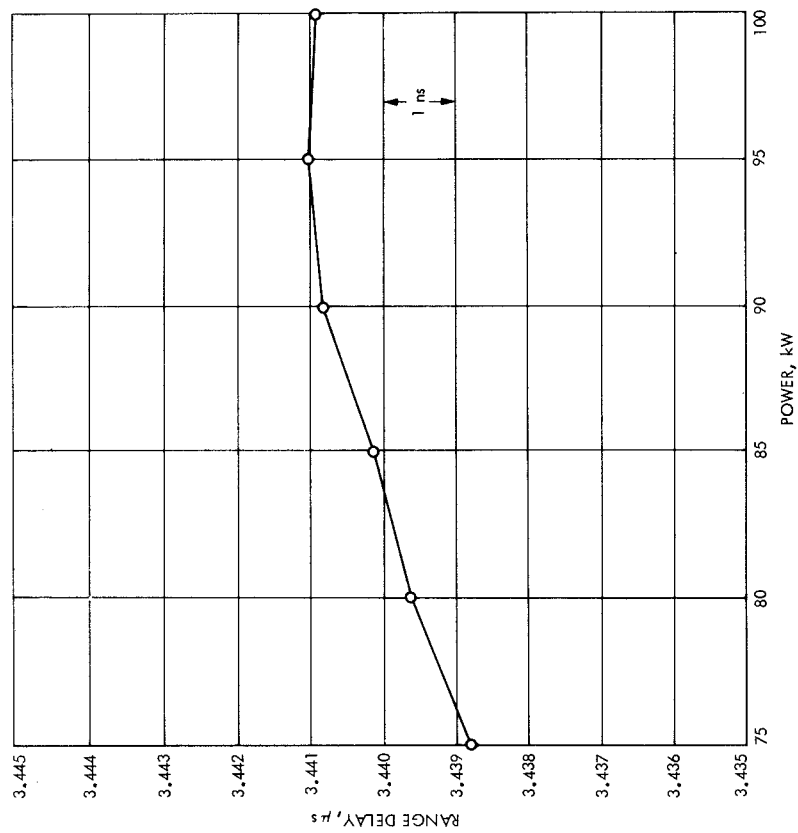


Fig. 3. 100-kW transmitter power vs ZDD S-band range on 1974 Day 75

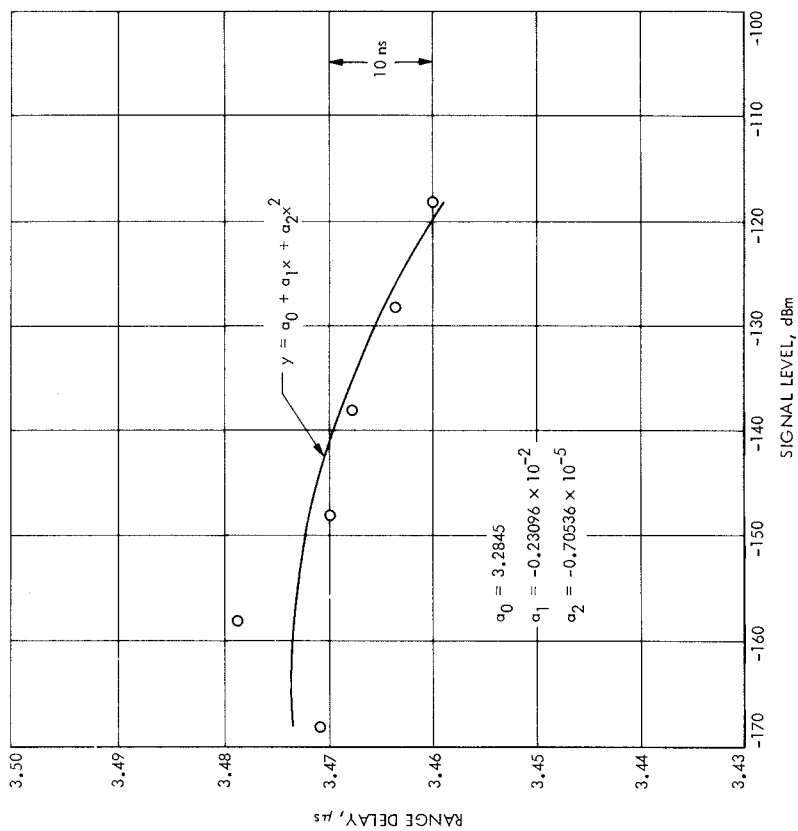


Fig. 5. Signal level vs S-range, 100 kW, ZDD test 1  
with RCV3 = S, 1974 Day 110

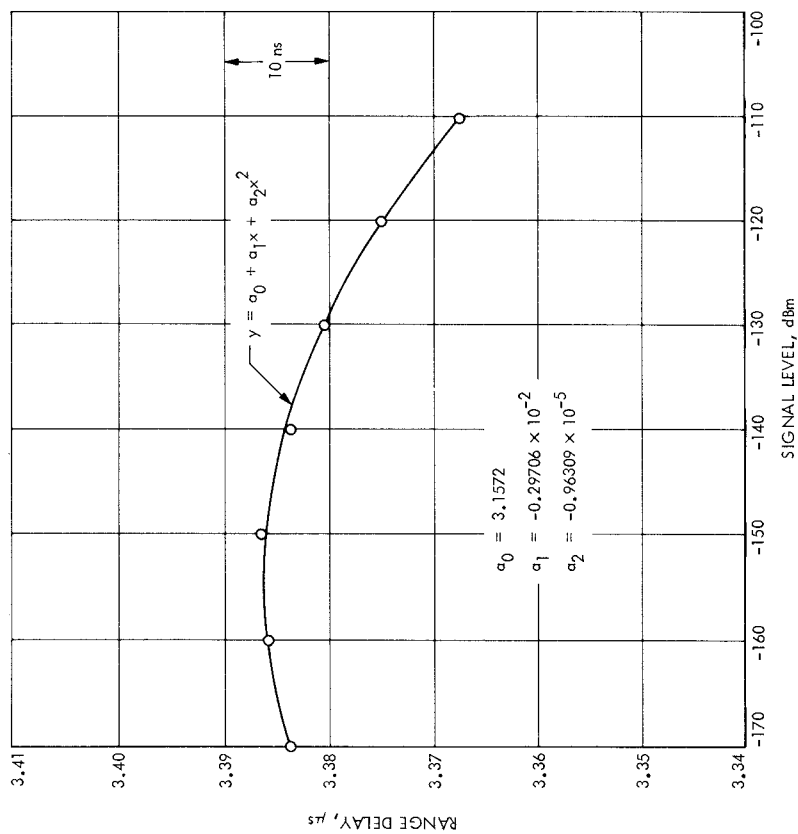


Fig. 6. Signal level vs X-range, 100 kW, ZDD test 2  
with RCV3 = X, 1974 Day 110

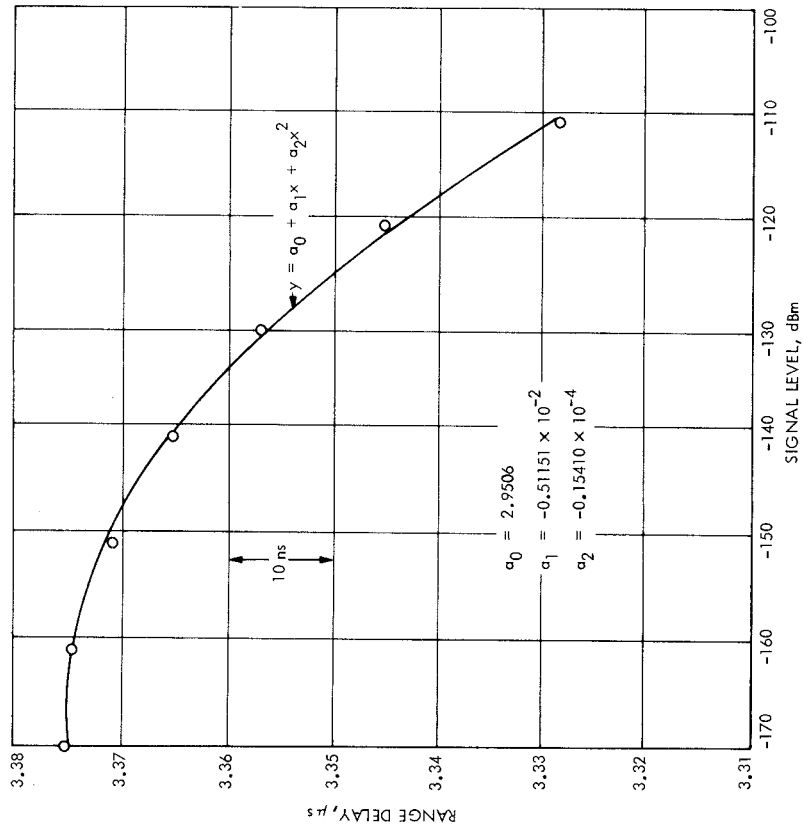


Fig. 7. Signal level vs X-range, 100 kW, ZDD test 1  
with RCV4 = X, 1974 Day 110

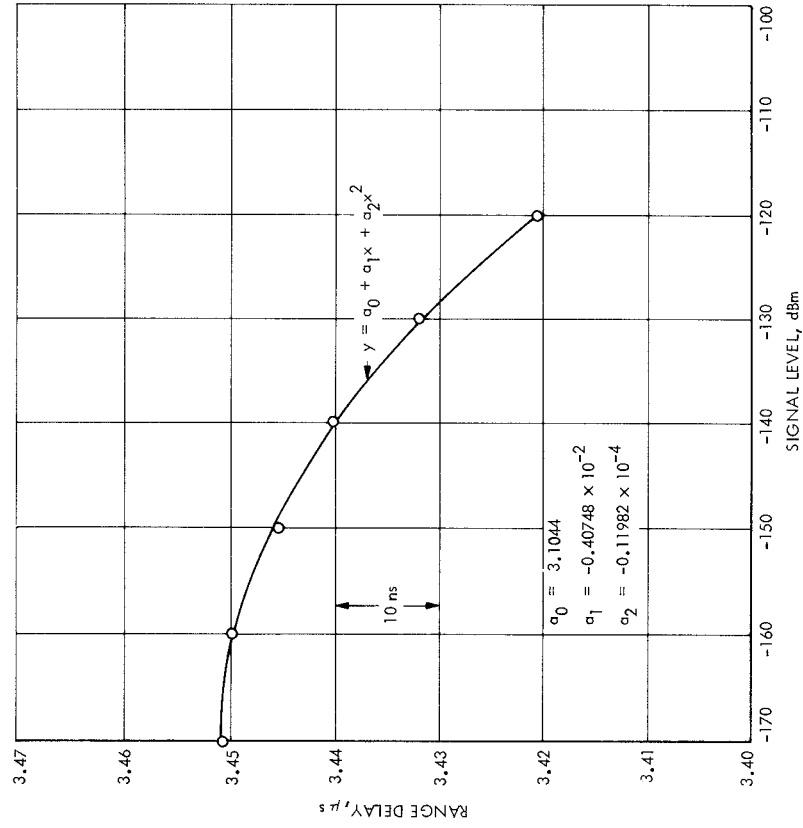


Fig. 8. Signal level vs S-range, 100 kW, ZDD test 2  
with RCV4 = S, 1974 Day 110



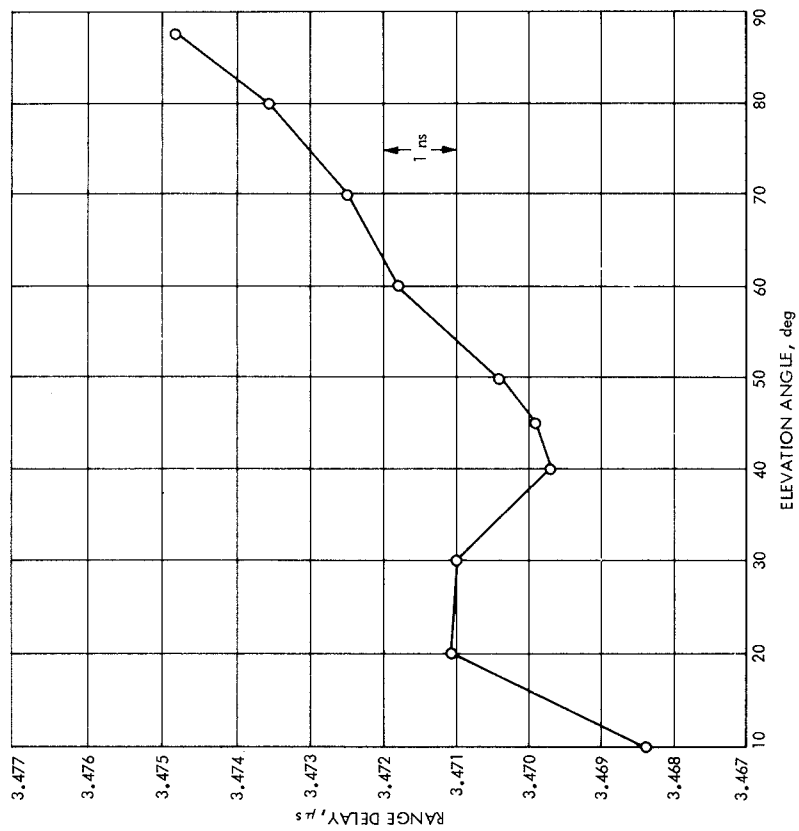


Fig. 9. S-range vs elevation angle via ZDD cable configuration,  
AZ = 220 deg, 100 kW, RCV3 = S, 1974 Day 157

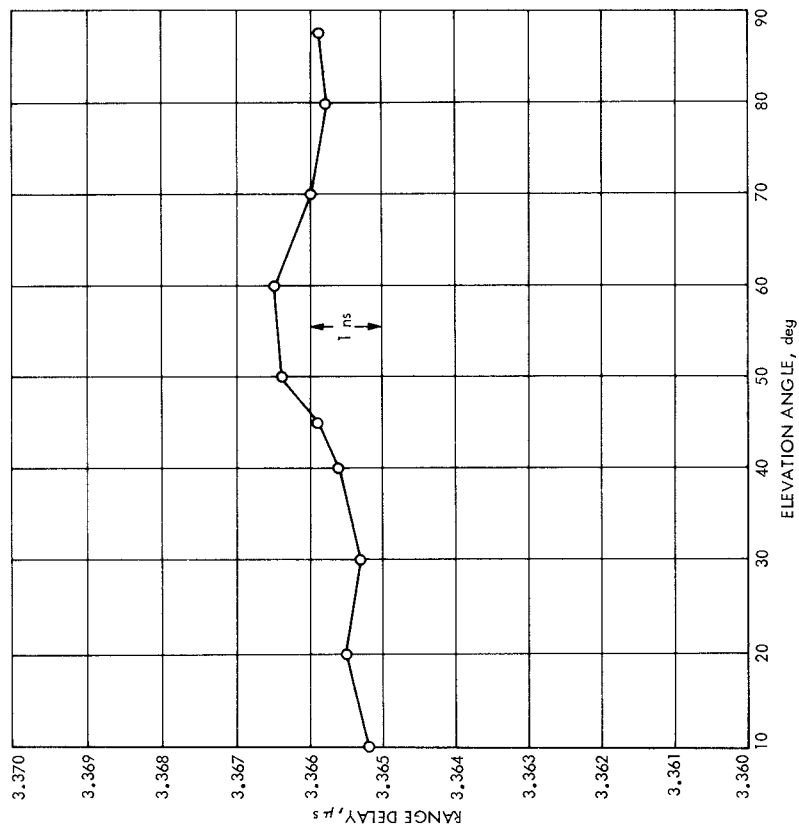


Fig. 10. X-range vs elevation angle via ZDD cable configuration,  
AZ = 220 deg, 100 kW, RCV4 = X, 1974 Day 157

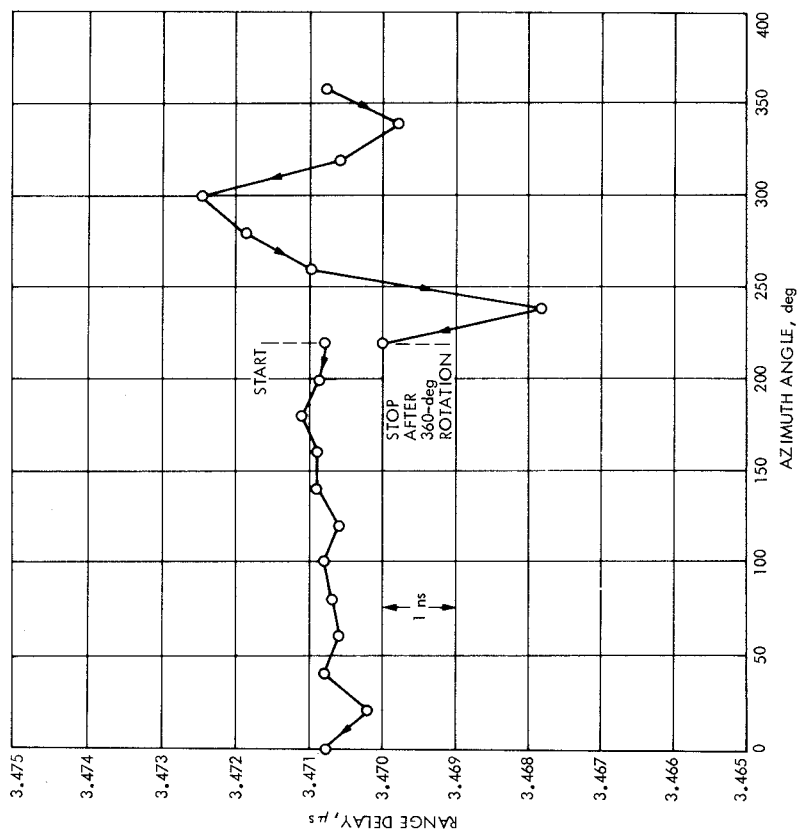


Fig. 11. S range vs azimuth angle via ZDD cable configuration, EL = 45 deg, 100 kW, RCV3 = S, 1974 Day 157

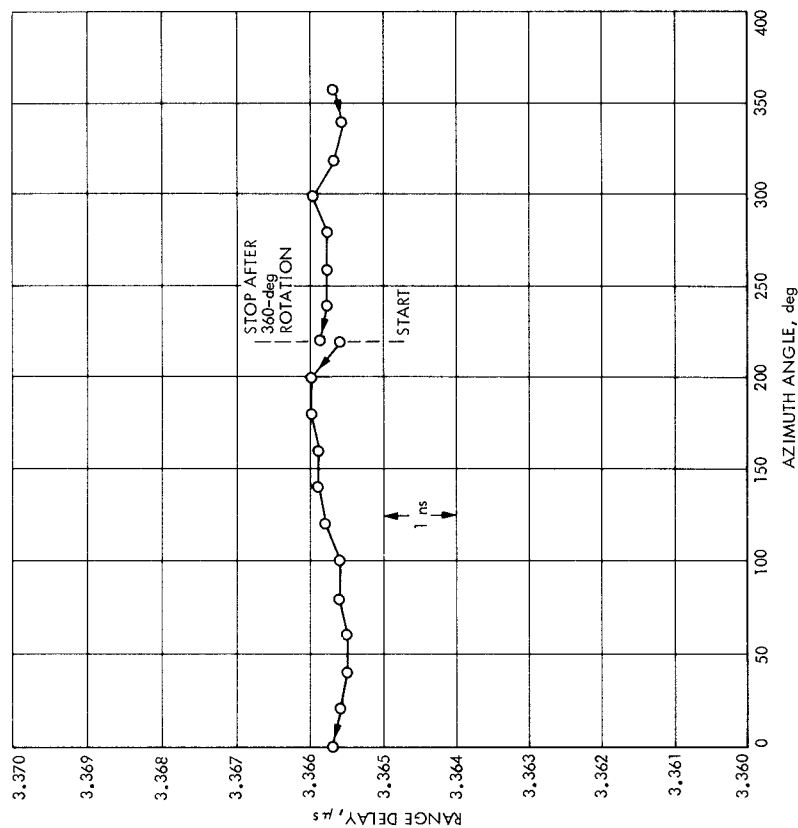


Fig. 12. X range vs azimuth angle via ZDD cable configuration, EL = 45 deg, 100 kW, RCV4 = X, 1974 Day 157

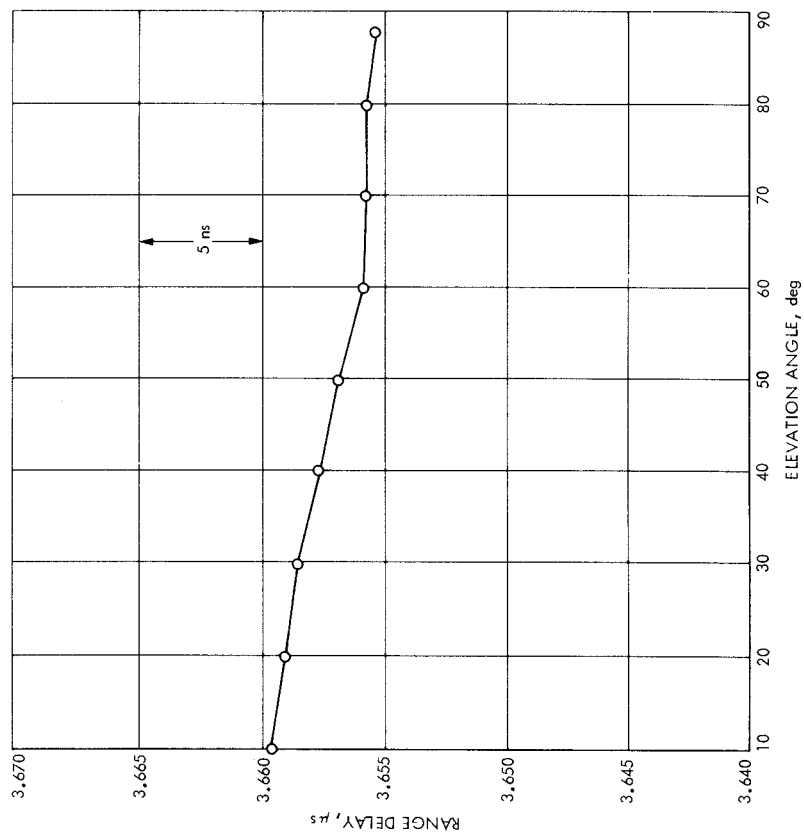


Fig. 13. S-range vs elevation angle via ZDD airpath,  
1974 Day 114

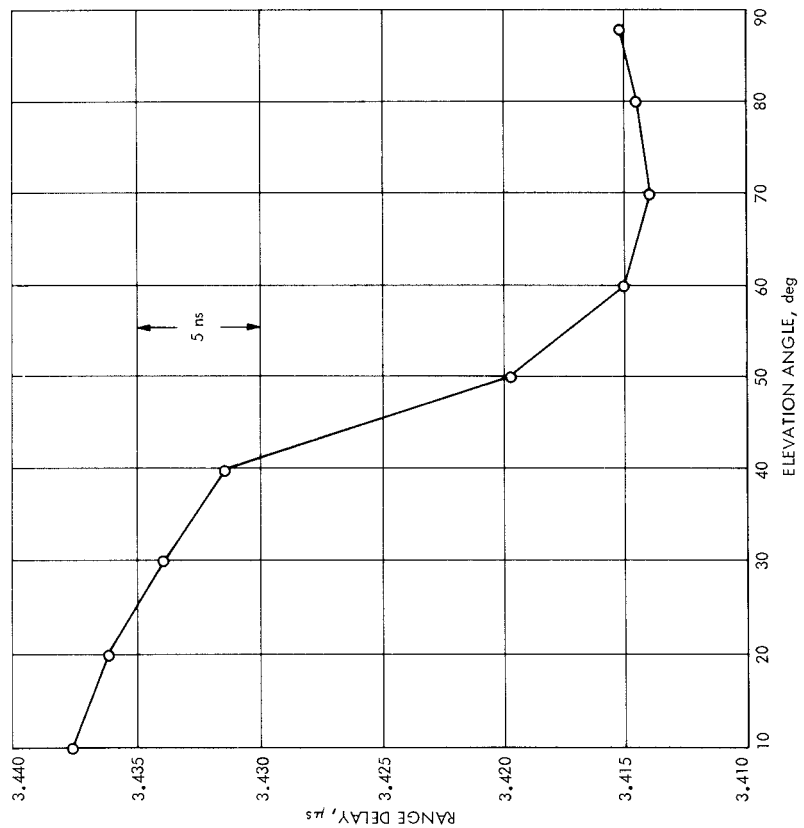


Fig. 14. X-range vs elevation angle via ZDD airpath  
(X-maser by-passed), 1974 Day 114